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THE DIVERSIFICATION OF THE CANE SUGAR INDUSTRY IN LATIN AMERICA AND THE CARIBBEAN*

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Introduction

The cane sugar industry was established in most of the Latin American and Caribbean countries after the colonial period and from then onwards these countries began to face sugar price fluctuations on the international market.

The sugar industry in the region comprises some 650 factories with a value of more than $US 15 billion. Output is approximately 30 million tons of sugar. In their technical level, the sugar factories lag behind the development of other industrial branches. Their technical obsolescence, the low level of maintenance and replacement and their special situation with regard to the use of fuel resources leave ample scope for improving efficiency and reducing costs.

Sugar-cane offers enormous possibilities for integrated processing by the industrial use of its by-products for the production of derivatives, with the aid of which it is possible to solve a number of problems that confront the countries such as demand for pulp and paper, boards, animal feed, and fuel requirements, generating income from export and/or import substitution.

In the context of a diversification strategy one can immediately envisage a whole range of possibilities offered by sugar cane in addition to the as yet unused potential of by-products, which is of fundamental importance in an industrial reorganization analysis.

With an output of 30 million tons of sugar, the volume of by-products generated by the regional sugar industry can help to solve demand for feedstuffs, fuels, pulp and paper, board, resins, plastics and other products.

Table 1

By-products obtainable with an
output of 30 million tons of sugar

BY-PRODUCTS	MILLION TONS
Bagasse, 50% moisture	66
Final molasses, 80° Brix	9
Filter cake, 77% moisture	9
Green leaves	25
Dry leaves	22
Cane top (green stalk)	22

Source: GEPLACEA - 1986

These figures show that the region has a broad raw materials base for the development and industrial processing of many products by the use of which the sugar sector can be diversified and expanded.

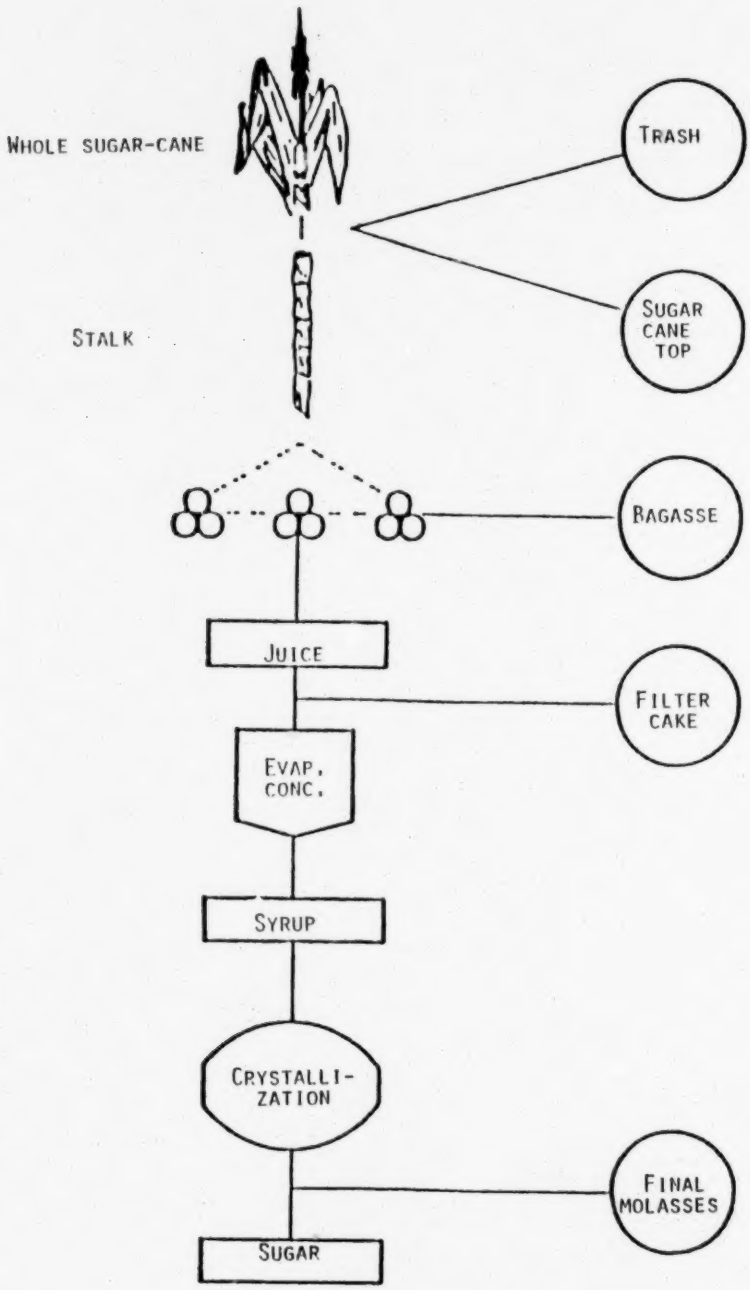
The purpose of the present paper is to show the development with regard to by-products that has been achieved in the region and the possibilities that are offered by diversification of the cane sugar industry.

1. By-products of the cane sugar industry and sugar-cane derivatives

Many by-products are obtained in sugar manufacture; they can be grouped according to the stage at which they occur, namely, those obtained during the harvesting of the cane, comprising green leaves, dry leaves, cane tops and fragments of sugar cane, commonly called harvest waste, and those that occur during the industrial process, such as molasses, bagasse and filter cake.

Figure 1

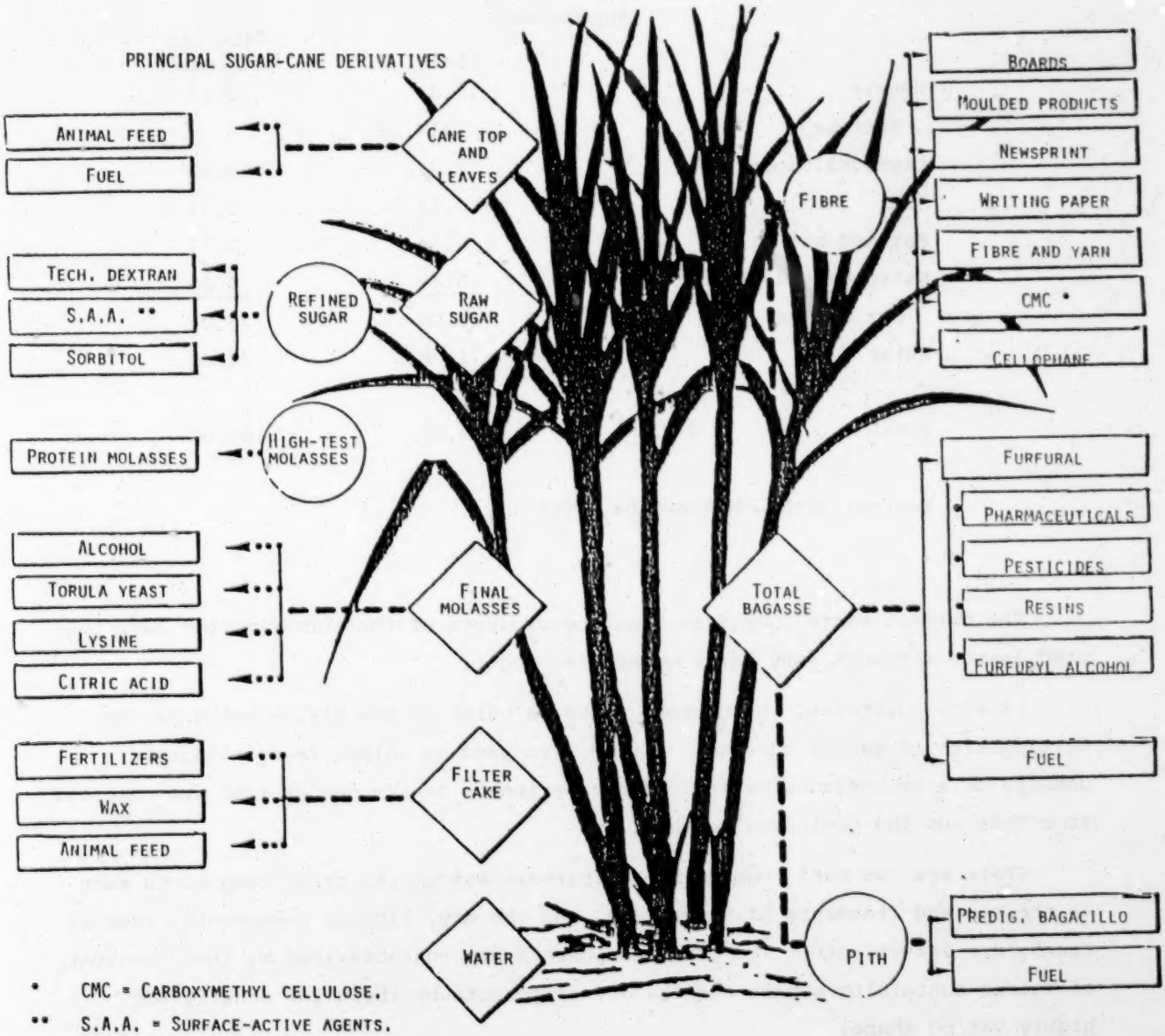
By-products of the cane sugar industry



Sugar-cane derivatives are defined as products that are obtained industrially from the by-products of the cane sugar industry: for example, molasses is a by-product and alcohol and torula yeast are derivatives obtained from the by-product molasses.

Figure 2, prepared by ICIDCA-MINAZ-Cuba, shows the by-products of the cane sugar industry as well as the main sugar-cane derivatives.

Figure 2



Sugar-cane consists basically of sugar, chiefly sucrose, and structural carbohydrates from the lignocellulosic complex, which have different uses. The saccharides of the sugar-cane yield intermediate or final products by fermentation or chemical means that have many possible uses in agriculture and cattle-rearing, the food, chemical, pharmaceutical and other industries. The lignocellulosic complex consists basically of cellulose, lignine and pentosans; it is possible to use these for the production of pulp and paper, boards, fuel, other by-products and for electricity generation.

Table 2

PERCENTAGE COMPOSITION OF SUGAR-CANE

(Approximate)

	Stalk	Cane top and leaves
Sugars	15.43	2.18
Sucrose	(14.1)	
Lignocellulose	12.21	19.08
Ash	0.54	2.31
Fat and wax	0.34	0.77
Nitrogenated compounds	0.48	1.66
Dry matter	29.00	26.00
Water	71.00	74.00
TOTAL	100.00	100.00

Source: ICIDCA-MINAZ-Cuba. 1985

The harvest waste comprises those by-products of the industry that have been used least, although very large quantities occur.

In many countries, the harvest waste is burnt on the fields owing to the difficulties of manual cutting. It is also used as animal feed, although usually on a spontaneous basis. Some experiments on its use as fuel are reported from Cuba and the Dominican Republic.

There are two basic components of harvest waste: the green components such as the top and fragments of sugar cane, and the dry, fibrous components, such as trash, dry leaves, etc. The green components are characterized by their content of juices containing sugars and the dry components by their low density and highly varied shape.

In general, harvest wastes have a high content of fibres and few proteins. By the use of fermentation processes, it is possible to improve their protein content and nutritive value. The low density of the wastes affects their transportation, so that in some countries methods are being studied of separating the various types and compacting them in order to improve their handling characteristics and reduce handling costs.

It is known in the region that bagasse can be used in the production of a number of derivatives such as pulp and paper, boards, and furfural and in the generation of electricity, so that there is experience of its industrial use, storage and separation methods.

The fact that bagasse is suitable for use as a fuel and is traditionally used for that purpose in sugar factories creates a competitive situation when the development of the industry for the production of derivatives from this raw material is analysed.

In most of the countries that produce cane sugar, it is necessary to use all the bagasse as fuel and sometimes large quantities are also used as additional fuel.

The utilization of bagasse as a raw material in the derivatives industry makes it necessary to analyse the size of the sugar-mills and their distance from one another, the link between sugar-mills and factories for the production of derivatives, and storage, transportation and depithing methods.

When bagasse is intended for use as a raw material in pulp, paper and board making, pith, which in most cases represents between 30 and 40 per cent of total bagasse, is obtained by depithing and can be used for generating steam or electricity and in animal feed.

In the region, molasses is used basically for the production of alcohol, yeasts, lysine, citric acid and animal feed. The principal problem affecting the use of molasses is its availability, since it sells at high prices on the international market.

Molasses can be obtained directly from sugar-cane in the form of high-test molasses or invert molasses. It is also possible to obtain A molasses or B molasses in the sugar-production process.

Sugar-cane juice is used directly in the production of alcohol and in some cases for animal feed. These processes offer the possibility of obtaining surplus bagasse.

No very profitable use for filter cake has as yet been developed, but on the other hand it is necessary to dispose of it as industrial waste. In many countries of the region it is used for watering fields or in irrigation channels. It is used in concentrated form in Cuba and Colombia as cattle and pig feed. The production of refined wax from filter cake offers prospects owing to the diversity of its uses in adhesives, for coating food and fruit, for crafts activities, bitumens, cosmetics, polishes and other purposes. In the region, Cuba has a semi-industrial plant for the production of refined wax, oil and resins.

2. Analysis of the situation in the region

The sugar-producing countries of Latin America and the Caribbean have a broad raw materials base for the development and industrial processing of a large number of products. There is a close link between the production of derivatives and the cane sugar industry, not only because of the quantities of by-products that are generated in the main industry but also because of the economic links between the processes, so that, among other factors, the size of the sugar-mills, the distance between them, the degree of agricultural and industrial modernization are important.

The availability of by-products is the determining factor in the industrial processing of derivatives, since the latter are generated as a logical consequence of sugar production and there is unquestionably a strong interrelation between the industry and its by-products.

Many examples of the development of different derivatives can be quoted in the region although if one considers the production of sugar and that of the by-products that are obtained as a logical consequence of their production, there is still great potential for the industrial processing of sugar-cane and its by-products. With regard to the industrial processing of derivatives, it can be observed that these and sugar are not considered together as lying within one sector, but that some of them are analysed in isolation, without taking into account the benefits that could be yielded by integrated development.

In most of the countries, with the exception of Brazil, where the production of alcohol is closely connected with that of sugar, there is no integrated approach to sugar and derivatives either. Generally, the sugar-mills sell off the bagasse and molasses, and sugar-producers are unaware of the benefits of their industrial use.

For the purpose of analysing the development achieved with regard to derivatives in the region, four major fields will be defined:

- Alcohol as a fuel and alco-chemistry;
- The utilization of sugar-cane by-products and derivatives for animal feed;
- The utilization of bagasse as a fuel, for energy generation, and the production of pulp and paper, boards and furfural;
- Other derivatives.

3. Alcohol as a fuel and alco-chemistry

Alcohol has traditionally been distilled in the sugar-cane growing countries, basically for the production of beverages and spirits for export and for highly specific uses in the perfumery and pharmaceutical industries. As from the 1970s, the traditional production of alcohol changed in the region and throughout the world with the introduction of Brazil's policy to produce alcohol as a substitute for petrol, accompanied by vigorous development of the alco-chemistry industry, i.e. the production of alcohol derivatives. Brazil has now 4.5 million ha of land in use for the production of sugar and alcohol and its planned output of alcohol in the present season is 13 billion litres. Brazil's policy with regard to alcohol is fully supported by the Government, this support being combined with vigorous development of the mechanical engineering industry.

Other countries in the region have substituted alcohol for petrol, including the following:

Argentina, which produces 495 million litres of anhydrous alcohol per year, basically for the domestic market;

Costa Rica sold 21 million litres of alcohol to the United States in 1986. It has also installed a dehydration plant with a capacity of 72 million litres to permit the purchase of hydrated alcohol and the production of anhydrous alcohol for export;

Bolivia produces 25 million litres of alcohol, which it uses as a substitute for petrol.

In other countries of the region, such as Honduras, Mexico, the Dominican Republic and Panama, among others, projects are being studied and analysed for the production of alcohol as a petrol additive, as a complete petrol substitute or for export to the United States.

The average cost of production reported in Brazil is 0.20 cents per litre. A distillery with a capacity of 120,000 litres/day has an average cost of between $US 6 and 7 million.

When, as in Brazil, alcohol is produced directly from sugar-cane, 3 kg of surplus bagasse is generated per litre of alcohol in independent distilleries. This bagasse is used in Brazil basically as a fuel for other industries and in some cases for electricity generation and as hydrolysed bagasse for animal feed.

The origin of alco-chemistry in Brazil dates back to 1920, when small quantities of acetic acid, ethyl ether and ethyl chloride were produced. At present, ethylene, acetaldehyde, acetic acid, butanol, butyl acetate and other chemicals are produced from alcohol. There are also projects for the production of other substances and for pilot plants.

In Peru as well there is a plant at Paramonga with an annual production capacity of 7,200 tons of PVC. It has four units for the manufacture of the final product: ethylene, dichlorethane, monomer and polymer plants. 2,000 tons of acetic acid is produced from alcohol and is used as raw material for the ethyl acetate, normal butyl acetate and isobutyl acetate industries.

The development of an alco-chemistry industry can be recommended in some developing countries because the plants are smaller in size than other plants in the chemical industry, require less investment and can be established in areas where the raw materials are available locally.

4. The use of sugar-cane by-products and derivatives for animal feed

The manufacture of feedstuffs from sugar-cane and its derivatives covers a wide range, from the simple use of wastes as such up to more sophisticated activities such as the production of lysine.

One of the advantages of basing animal feed production on the cane sugar industry is the low cost of the investments involved. Another factor to be stressed is the experience gained in the region by a number of countries such as Cuba, Colombia, the Dominican Republic and Brazil.

In Cuba, animal feed production on the basis of the cane sugar industry has been developed vigorously. The substances used for this purpose are sugar-cane direct, and mixtures of molasses and urea, and of molasses, urea and bagacillo, and predigested bagacillo; also, harvest wastes are processed, filter cake being dried for use as cattle-feed. There is also production of forage yeast, protein molasses and saccharomyces yeast; the production of cane syrup and intermediate molasses is under study.

Brazil produces hydrolysed bagasse, which is mixed with other products for use as feed for cattle when they are fenced in.

In Colombia, sugar is used as replacement poultry feed, and great progress has also been made in producing animal feed on the basis of the cane sugar industry.

In the La Romana sugar-mill in the Dominican Republic, there has been vigorous development of cattle-feed production from cane sugar industry by-products.

In Mexico as well, cattle-feed is produced from molasses and there is a plant for the production of 7,000 tons/year of lysine. This lysine plant is the only one reported in the region.

In almost all countries of the region, animal feed has been produced to a greater or lesser extent from cane sugar industry wastes. In the production of animal feed from cane sugar industry by-products, there must be closer integration between cattle farmers and sugar producers.

Various research projects have been under way for a number of years in several countries, principally Cuba, the Dominican Republic and Colombia, with the object of ascertaining the genuine potential of sugar-cane and the most appropriate handling and processing system. There have also been numerous nutritional research projects on the basis of which it can now be stated that sugar-cane can be the source par excellence for animal feed in the tropics.

5. The utilization of bagasse as a fuel, for energy generation, and the production of pulp and paper, boards and furfural

The high price of petroleum and its availability indicate a change in the criteria established with regard to the industrial use of bagasse. In most of the cane sugar producing countries, when bagasse has been industrially processed, it has been replaced as a fuel by petroleum products, thus increasing raw material prices. On the other hand, when surplus bagasse is used, only half the amount is available, so that new criteria must be found for the study of plant capacity and for investigating economies of scale by comparison with the costs of transportation and the replacement of bagasse as a fuel.

In the region, there are reports of paper production from bagasse in Argentina, Brazil, Colombia, Cuba, Mexico, Peru and Venezuela. The production of printing and writing paper from bagasse offers no difficulty and installations have been in existence for several decades.

Recently, three countries, Argentina, Mexico and Peru, have constructed plants with capacities in the 100,000 tons/year range for the production of newsprint from bagasse.

In this context, special mention should be made of the Tucuman newsprint plant, which has improved and optimized its original technology and produces paper to satisfy the needs of the domestic market and some quantities for export.

The investment cost of the plant was $US 300 million per ton; under present circumstances, prices do not cover total costs - only the variable costs but not the fixed costs. Also, the products must be exported to nearby countries so as not to burden the price with freight costs. Newsprint from Tucuman supplies 110 Argentine daily newspapers and its share of the local market has risen to 35 per cent. This newsprint has also been exported to a number of countries, such as the United States, Brazil, Venezuela, Peru, Uruguay, Paraguay, Bolivia and Thailand.

The investment cost of the Mexican newsprint factory was approximately $US 100 million. At the moment, it produces newsprint by the conventional soda process and exports most of its output, principally to the United States, Central America and Brazil.

The newsprint factory installed in Peru has closed down owing to some problems, chiefly in the economic field.

In Venezuela, a technology has been developed for the production of newsprint from bagasse, although there are still problems with the rotary printing presses.

In Cuba, a semi-industrial plant for the production of newsprint with a capacity of 9,000 tons/year was installed at an investment cost of $US 25 million. In this plant, the chemicals are not processed for re-use and low production costs for paper are reported.

There has also been some development of the production of boards in the region, although in certain countries such as Jamaica and Mexico the plants installed are not working. Cuba reports the existence of seven plants with a capacity of 275,000 m^3/year.

Special mention should also be made of the plant installed in Venezuela, where the boards are used in making furniture and in the construction industry.

There is a 40,000-tons capacity plant in the Dominican Republic for the production of furfural from bagasse, which operates basically for export. Brazil has a plant with a capacity of 3,500 tons/year; furfuryl alcohol is also produced.

Much research has been carried out in Cuba on furan derivatives and there is a project to install a furfural plant in the near future.

An important feature of the production of furfural is the high consumption of bagasse per ton of output. The investment for a 5,000-ton plant is approximately $US 20 million, and production costs are $US 800-1,000 per ton.

Other derivatives

In addition to those indicated above, other derivatives are produced in the region, a fact that it is useful to mention in this paper, since its principal purpose is to show the progress that has been made in this field.

Baker's yeast is produced in many countries of the region. In Mexico and Brazil, citric acid is produced from sugar and monosodium glutamate from molasses, both by fermentation. Monosodium glutamate is also produced in Peru.

Vinasse is concentrated in Mexico, and research on its concentration is being conducted in Cuba and Brazil.

In Brazil, lactic acid, sorbitol, mannitol, fatty acids and sucrose esters are also produced. In this country, in addition to the development of alcochemistry, a strong trend towards the development of sucrochemistry can also be observed.

In Cuba, dextran is produced from sugar and refined wax from filter cake, and there is a semi-industrial plant that produces dissolving pulp from bagasse.

The countries of the region are also studying the most efficient way of utilizing the wastes of the plants established, and efforts are being made to solve the problems of environmental pollution and to find solutions for fertilization, energy and other problems.

CONCLUSIONS AND RECOMMENDATIONS

- In the analysis of the situation in the region with regard to the diversification of the cane sugar industry in the Latin American and Caribbean countries, it should be emphasized that there is great potential for by-products and the industrial processing of a number of derivatives, and that these countries have some experience of research and development work.

- Diversification of the cane sugar industry not only provides a solution to the market situation for this product but also an answer to other problems faced by the sugar-producing countries.

- The direct utilization of sugar-cane and/or the by-products of the cane sugar industry provides feedstuffs, fuels, pulp, paper and board and also permits the development of the biochemical and chemical industries on the basis of an annually renewable resource.

- It follows from the above remarks that it is desirable to implement an interregional programme that would contribute towards reducing costs in the industry, raising efficiency in the technological sphere and in the use of fuels, expanding the production of derivatives and promoting integration in this context, thus developing the present cane sugar industry.

- It is also necessary to create an infrastructure capable of promoting methods and systems for technical co-operation and exchange of knowledge and experience that will provide the countries, institutions and officials with the necessary elements to permit rapid decision-making, taking into consideration the particular conditions of each country.

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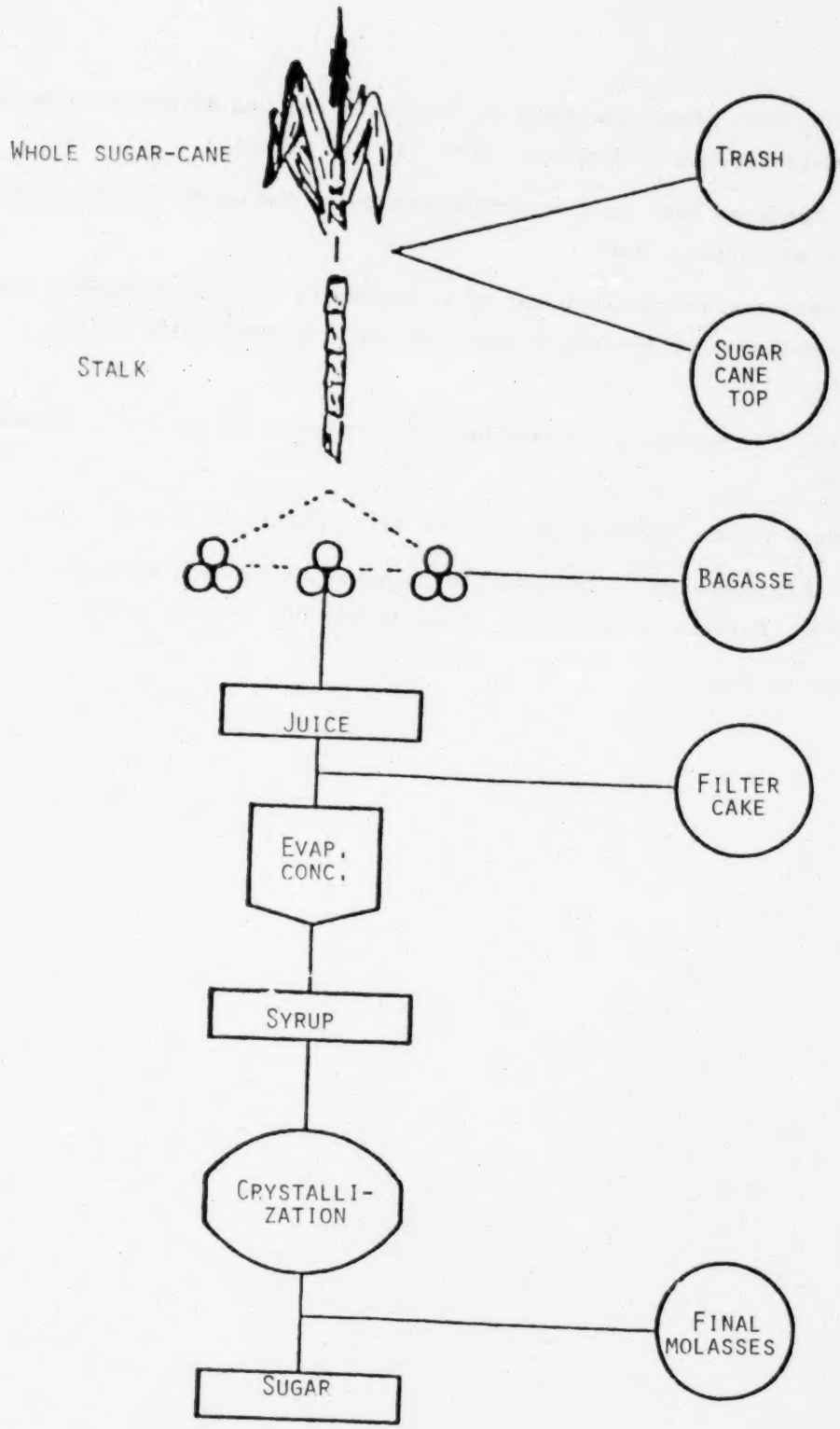
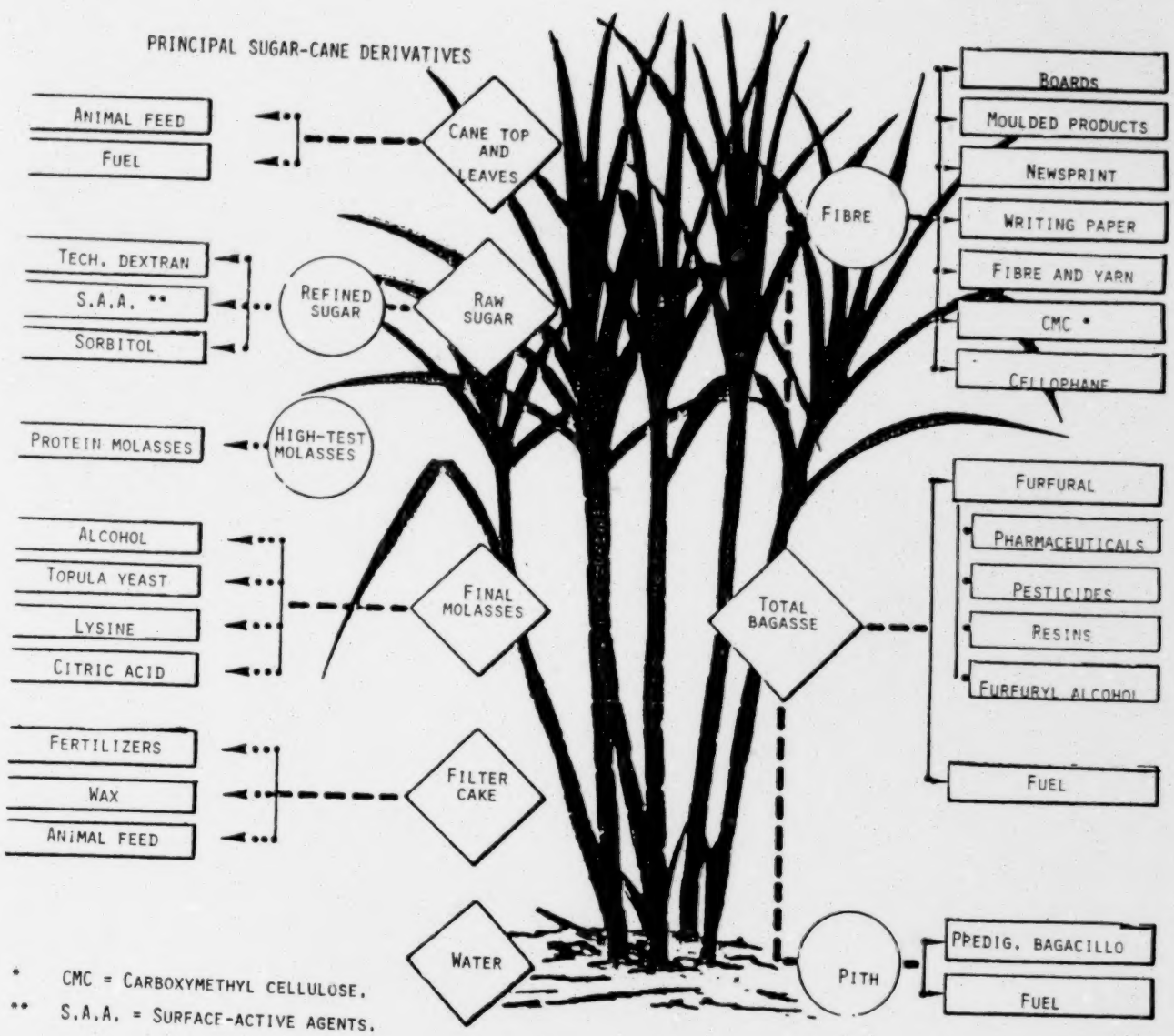

WHOLE SUGAR-CANE
TRASH
STALK
SUGAR CANE TOP
BAGASSE
JUICE
FILTER CAKE
EVAP. CONC.
SYRUP
CRYSTALLI-ZATION
FINAL MOLASSES
SUGAR


PRINCIPAL SUGAR-CANE DERIVATIVES
ANIMAL FEED
FUEL
CANE TOP AND LEAVES
TECH. DEXTRAN
S.A.A. **
SORBITOL
REFINED SUGAR
RAW SUGAR
PROTEIN MOLASSES
HIGH-TEST MOLASSES
ALCOHOL
TORULA YEAST
LYSINE
CITRIC ACID
FINAL MOLASSES
FERTILIZERS
WAX
ANIMAL FEED
FILTER CAKE
WATER
FIBRE
BOARDS
MOULDED PRODUCTS
NEWSPRINT
WRITING PAPER
FIBRE AND YARN
CMC *
CELLOPHANE
TOTAL BAGASSE
FURFURAL
PHARMACEUTICALS
PESTICIDES
RESINS
FURFURYL ALCOHOL
FUEL
PITH
PREDIG. BAGACILLO
FUEL
* CMC = CARBOXYMETHYL CELLULOSE.
** S.A.A. = SURFACE-ACTIVE AGENTS.